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Improving Road Transport Operations using Lean Thinking

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Abstract

This paper documents a case study where the transport operations of a word leading provider of paper-based packaging solutions operating in Bogota, Colombia, were measured and improved using lean concepts, methods and tools. The methodology consisted of: (1) direct observations of the transport operations; (2) collection and analysis of data; (3) creation of a Transportation Value Stream Map (TVSM); (4) measurement of the Transportation Overall Vehicle Effectiveness (TOVE); and (5) proposal of improvement recommendations. The TVSM identified six wastes: waiting, resource utilisation, excess movement, over-production, over-processing and behavioural. The TOVE measure resulted in an efficiency of 54%. The study proposed improvement recommendations based on the results of the TVSM and TOVE.

Keywords: Lean thinking; transport operations; Value Stream Mapping; waste elimination; Overall Equipment Effectiveness.

1. Introduction

Transportation and distribution are considered tertiary economic activities [1]. However, globalised markets and international trading have transformed this activity from being a less important, and perhaps even forgotten, business element into a differentiating factor that adds service value to customers [2] and significantly impacts the overall operational performance of organisations. This has forced many manufacturing organisations to not only

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focus on improving their 'factory-based operations' but also their logistics and transport operations. Specifically, the improvement of road transport operations has been traditionally and mainly addressed through mathematical modelling and new generation algorithms supported by powerful software tools [3]. However, recent research has demonstrated the suitability and effectiveness of lean thinking to also drive such improvements [4,5,6,7,8]. Since its conception by Toyota Motors several decades ago, strong evidence suggests lean as an effective method which aids organisations to be more competitive [9]. This has contributed to make lean the most influential paradigm in manufacturing [10]. Nevertheless, despite its wide success and acceptance worldwide, its application to road transport operations has been limited [7], but the aforementioned evidence indicates that its application has now started to be more widely explored in this industrial sector.

In terms of the results obtained from the application of lean thinking to drive improvements in road transport operations, the results obtained from the study of Villarreal et al. [4] showed a 27% reduction in the number of distribution routes while distance travelled was also reduced by 32%. Similarly, after the application of lean thinking in a Mexican organisation that processes and distributes bottled beverage, Villarreal et al. [5] reported a reduction of average serving time from 40.6 mins to 18.7 mins, a significant reduction of the average route preparation time from 90 mins to 23 mins and of the average route closing time from 60 mins to 16 mins. Similar improvements in the reduction of number of routes, distance travelled, excess service time, demand not satisfied, and emission of harmful gases as well as increases in Transportation Overall Vehicle Effectiveness (TOVE), average number of clients served per route and vehicle capacity utilisation were also reported by Villarreal et al. [6], Villarreal et al. [7] and Garza-Reyes et al. [8].

This evidence motivated the authors of this paper to apply lean thinking concepts, methods and tools to measure and drive the improvements of the road transport operations of a world leading provider of paper-based packaging solutions operating in Bogota, Colombia. This organisation currently operates in 34 countries around the world with more than 340 production sites, and around 45,000 employees worldwide. In Colombia, the case organisation operates a total of four corrugated factories located in Barranquilla, Medellin, Cali and Bogota. In particular, the Bogota site distributes its products inside the central region of Colombia. Due to a constant growth in demand, the site has increased its production capacity through capital investment in new equipment. This had resulted in the dispatch and distribution departments to be stretched and converted into bottlenecks within the transforming value stream of the organisation's products. This paper therefore documents a case study where the road transport operations of the case organisation were measured and improved using lean thinking. The paper adds evidence to the recent scholar research which shows the suitability and effectiveness of lean thinking for the improvement of logistics and transport operations.

2. Analysis of road transport operations

2.1 Methodological approach

The overall methodological approach followed to improve the road transport operations of the studied organisation by using lean thinking is showed in Fig. 1. In this case, the road logistics operations were divided into four contexts, namely: (1) Initial activities Not in transit, (2) Service clients, (3) Transit, and (3) Final activities Not in transit. The first included activities from preparing orders and routes until leaving the manufacturing plant, whereas the second included activities that were exclusively related to the service of customers. The third included activities' time between the manufacturing plant and customers, and between one costumer and other. The fourth corresponded to those activities carried out after the order had been delivered and until the route was closed. For every context, a TVSM and TOVE analyses were conducted by following the steps shown in Fig. 1. TVSM is a tool adapted by Villarreal [11] from the traditional Value Stream Mapping (VSM) tool [12] to support the improvement of efficiency initiatives in road transport operations. TVSM focuses on identifying wastes related to transport activities [4]. On the other hand, TOVE is an extended version of the Overall Equipment Effectiveness (OEE) indicator used by the lean's Total Productive Maintenance (TPM) approach to improve the effectiveness of production equipment [4,11] and the Overall Vehicle Effectiveness (OVE) measure proposed by Simmons et al. [13]. Besides the traditional availability, performance and quality metrics considered by OEE, TOVE does not only consider these three within the context of road transport operations/wastes but also the administrative availability metric. Unlike OEE, since vehicles represent a high capital investment and hence must be kept in operation at all times [11], TOVE also considers total calendar time, as opposed to simply considering loading time.

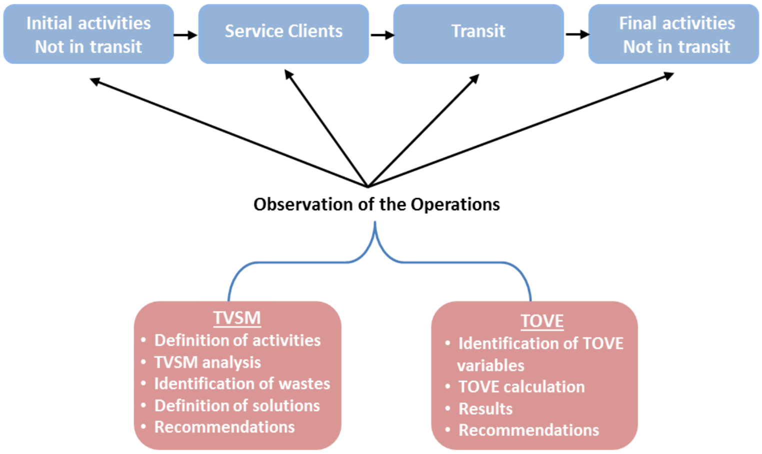

Fig. 1. Methodological approach followed to conduct the improvement of road transport operations using lean thinking.

The data to construct the TVSM and calculate the TOVE was mainly collected through direct observations, although a small part of it was also gathered from an administrative information system supported by the drivers' handhelds and trucks' GPS. Based on the work of Villarreal et al. [4], a sample of 30% of the daily routes was considered appropriate to support the creation of the TVSM and calculate TOVE. This resulted in a total of five observations being taken to define the activities that comprised every one of four contexts, see Fig. 1, and measure the performance of the road transport operations of the case organisation. The results are shown in Table 1. The concept of 'trimmed mean' [14] was employed to disregard observations affected by assignable cause variations [15], i.e. 225 mins in observation 2 and 1430 mins in observation 3, and in this way capture the real process.

Table 1. Observations results.

Road Transport Operations		Routes – Observations (minutes)					
		1	2	3	4	5	Trimmed mean
Initial	Preparing orders (planning)	35	38	45	42	32	38
	Picking orders to outbound area	55	33	15	29	42	35
	Loading time	35	225	68	20	26	75
	Loading time expected for the company	0	0	0	0	0	0
	Documentation (certification, invoices, etc)	33	19	18	20	56	29
	Truck inspection	0	0	0	0	0	0
	Close loading and set the truck for route	10	11	12	25	5	13
	Truck inspection time (frequency of scheduled maintenance)	0	0	0	0	0	0
	Total initial process	**168**	**326**	**158**	**136**	**161**	**156**
Serve clients	Waiting time for available space in each customer	28	35	28	41	1430	312
	unloading time per customer during the route	134	43	125	28	31	72
	Unloading time expected	0	0	0	0	0	0
	Time loading spoiled poducts	0	0	0	0	0	0
	Inspection and recollection of documents	0	0	0	0	0	0
	Inspection quality and complete order	0	0	0	0	0	0
	set the Truck for the next customer	22	15	16	12	14	16
	Time extra in services	0	0	0	0	0	0
	Total time truck per each customer	**184**	**93**	**169**	**81**	**1475**	**132**
Transit	Time between each customer	34	62	34	28	66	45
	Time from customer to plant and return documents	76	88	35	51	60	62
	Average speed	43	40	55	34	60	46
	Driver breaks	0	0	0	0	0	0
Final	Unloading spoiled product	0	0	0	0	0	0
	Total transit time	**110**	**150**	**69**	**79**	**126**	**107**
	Total journey time	**462**	**569**	**396**	**296**	**1762**	**385**

2.2 Transportation Value Stream Mapping analysis

The data obtained from the observations presented in Table 1 were used to construct the TVSM and carry out its analysis. As suggested by Villarreal et al. [4], macro and micro level TVSMs were constructed to study and understand the generic (macro) and specific (micro) activities of the road transport operations studied. Fig. 2 presents the (a) macro TVSM, (b) micro TVSM, and (c) TVSM-wastes.

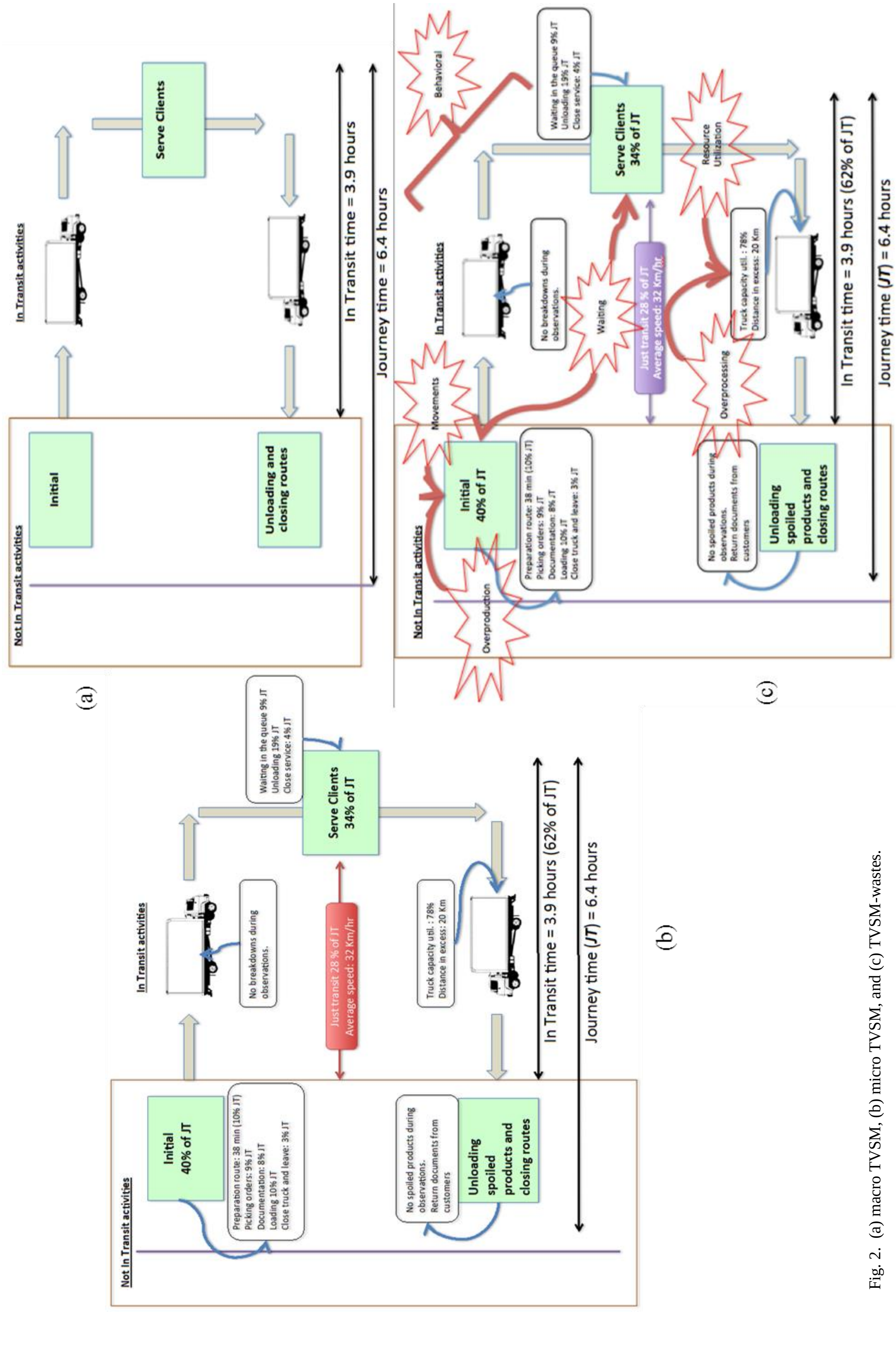

Fig. 2. (a) macro TVSM, (b) micro TVSM, and (c) TVSM-wastes.

The TVSM was mainly divided into Not-in-Transit (NIT) and In-Transit (IT) activities. The macro TVSM, see Fig. 2(a), indicated that the total average journey time (NIT + IT activities) was 6.4 hours, with NIT activities accounting for 2.5 hours (about 40% of the total journey time) while IT activities accounted for 3.9 hours (about 60% of the total journey time). NIT activities can be more easily controlled by the case organisation as those occur within the company's environment and premises while many factors affecting IT activities, e.g. traffic jams, strikes, customer situations, etc., are in many cases out of the control of the company [4,6,8]. Thus, improvement efforts to reduce the total journey time could initially focus on eliminating waste of NIT activities as suggested by the lean philosophy [9]. The micro TVSM, see Fig. 2(b), showed that the proportion of all NIT activities was very similar for all of them, e.g. preparing the route took 10% of the NIT time, picking orders took 9% of this time, preparing documentation took 8% of the NIT time, etc., see Fig. 2(b).

In the case of IT activities, this group consisted of two components, namely: (1) the physical transit of the truck and the (2) service of customers. In the case of the physical transit of the truck, it represented 28% of the total journey time with an average speed of 32 km/hr. The average speed of the delivery trucks is a factor that was not monitored, measured and controlled by the case organisation. Hence, implementing these actions can be an important initial step to reduce the time it represented within the total journey time (i.e. 28%). In addition, the micro TVSM analysis showed that truck capacity utilisation was 78%, which clearly highlighted it as an opportunity for improvement. Furthermore, the micro TVSM analysis showed a total distance in excess of 20km for the 5 observations, indicating an average of 4 km per observation. The main reason for this was traffic congestions that were tried to be avoided by the drivers by taking a different route. The incorporation of GPSs with real time traffic information can help the case organisation to improve this parameter. In terms of the second component, i.e. service of customers, it contributed to 34% of the total journey time, see Fig. 2(b). Within this component, unloading the product contributed to 19% of the total journey time, making it the longest of all activities (NIT and IT) of the road transport operations of the studied organisation. The main reason was that customers did not have the same amount of resources as the case organisation in terms of staff and lift trucks. Waiting in the queue for available space in the customers' dock was also an important contributor to the total journey time, accounting for 10% of it. This calls for a better integration, coordination and delivery schedule between the case organisation and its customers so waiting time for space in the docks to download product can be minimised as much as possible and enough resources are assigned beforehand to the unloading of the truck.

Table 2 summarises the wastes identified through the TVSM analysis. These are also illustrated through Fig. 2(c).

Table 2. Transportation wastes.

Wastes	Activity	Details
Waiting	• Picking orders to outbound area. • For available space in the customer	• Looking for inventory • Waiting for the production of the order • Lift truck driver is busy • Queue in the customer place
Resource utilisation	• Loading the truck	• 78% truck capacity utilisation
Movements	• Picking orders	• Unnecessary movements looking for inventory in the plant
Overproduction	• Documentation	• 5 documents that take an average of 29 minutes
Over-processing	• In transit	• Distance in excess: 20 Km in the 5 observations
Behavioural	• All activities	• No targets during the processes

2.3 Transportation Overall Vehicle Effectiveness calculation

Table 3 shows the calculation of the TOVE, the different elements that comprise it (i.e. quality efficiency, performance efficiency, administrative availability efficiency, and operating availability efficiency), the transportation losses that every one of the elements represent, and the key performance indicators (KPIs)/formulas that were used for the calculation of the elements and TOVE.

Quality efficiency = 90%. Losses due to 'demand not met' were the main factor affecting the quality component with 20% of this demand not having been delivered to customers. The problem, in this case, was the lack of effective communication between the studied company and its customers. On the other hand, orders were delivered without spoiled products; therefore, the 'non-product defects' indicator resulted in 100% efficiency.

Table 3. TOVE calculation results.

TOVE					
	Services losses	KPIs	Indicator	Average	
Quality efficiency	% demand not met	# orders deliveries on time / Total orders	80%	90%	
	% Non Product defects	1-# Spoiled goods/ Total order	100%		
	Capacity losses				
Performance efficiency	Fill loss	M2 orders / M2 capacity of the truck	78%	72%	
	Speed Loss	average speed (trucks) / Average speed (city and streets)	52%		
	Excess distance	Distance recommended by GPS / distance traveled	86%		
	Availability losses				TOVE 54%
Administrative availability efficiency	Nonscheduled time	1- Unexpected meetings, training, maintenance/ Total expected meetings, training, maintenance	100%	100%	
	Scheduled maintenance	expected meetings, training, maintenance/ Total expected meetings, training, maintenance	100%		
Operating Availability Efficiency	NIT activities	Expected total time NIT activities / Real time NIT activities	87%	83%	
	Excess load and unload time	Expected loading + unloading time/ Real loading + unloading time.	44%		
	Driver Breaks	Duration total breaks / total in transit time.	100%		
	Unscheduled maintenance	Duration breakdown / total in transit time.	100%		
	Waiting and excess service time	Expected waiting and service time / Real waiting and service time.	85%		

Performance efficiency = 72%. As previously revealed by the TVSM analysis, the case organisation had a 12% under-utilisation of the capacity of its delivery trucks, resulting in an important area for improvement. This was corroborated by the TOVE calculation, see Table 3. In terms of performance efficiency, ‘speed losses’ represented the major loss within this component. This mainly came from the lack of use of driving aid technology (e.g. GPSs) as this activity was mainly based on the experience and knowledge of the drivers. The same occurred with the last indicator of ‘excess distance’, which resulted in 86%.

Administrative availability efficiency = 100%. The maintenance and trainings were carried out according to previous schedule. This was verified with the comparison between scheduled and original documents that guaranteed the accomplishment of these activities. Furthermore, during the observations no unscheduled training or maintenance was found.

Operating availability efficiency = 83%. ‘Driver breaks’ and ‘unscheduled maintenance’ resulted with 100% efficiency, showing an effective preventive maintenance programme at the studied organisation. The rest of the metrics presented some room for improvement, see Table 3. In particular, ‘loading and unloading’ (44%) activities were defined as a critical element which the case organisation could focus on in order to improve the operating availability efficiency element and TOVE.

TOVE = 54%. The overall result of the twelve indicators is represented through the TOVE measure, which in this case showed a transportation overall vehicle effectiveness of 54%. Like OEE, TOVE can be used not only to monitor and control the performance of the road transport operations of the studied organisation but also to guide its improvement initiatives, prevent the sub-optimisation of its delivering trucks, and establish targets for its road transport operations [16].

3. Improvement recommendations

Fig. 3 illustrates the relationship between the potential solutions proposed by the authors and the different activities of the road transport operations of the studied organisation. It also shows that all recommendations will potentially have a positive impact on the TOVE indicator.

a. Targets. The study identified as the most important issue in the case organisation the lack of goals in the main transportation activities. When employees do not have goals for each operation it is not possible to control them and hence it is difficult to improve their efficiency. Thus, the company should define targets for each activity (they should start with loading, unloading, picking order to outbound area and documentation). The targets should be physically displayed where the activity takes place and be controlled by top managers, who should also provide feedback periodically. In addition, the results for each shift should be shown where they can be easily seen in order to encourage improvement between shifts. The definition of the KPIs should be carried out carefully. The case company can use the TOVE indicators and targets should be set by following the S.M.A.R.T (Specific, Measureable, Assignable, Realistic, Time-related) approach.

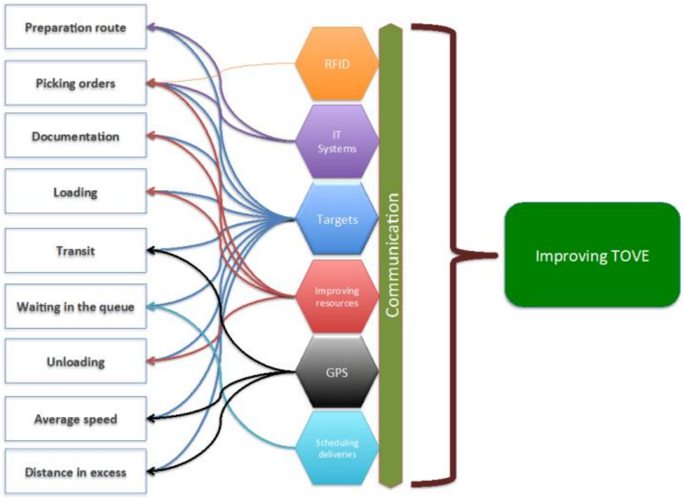

Fig. 3. TVSM-wastes-solutions and improvement of TOVE.

b. IT systems. Fig. 2(c) showed that 'documentation' contributed to 8% of the total journey time. This can be considered a non-value added activity. The study identified five critical documents that any route needs to process and have before leaving the plant. Each document was provided/captured by different software. Thus, the authors recommended the integration of all five documents into a single and unique software to facility this activity. This would also allow the synthesis and centralisation of the data for easier analysis regarding other elements of the process (i.e. business intelligence). This can contribute to decision making and highlight improvement opportunities.

c. Increasing – improving resources. Fig 2(c) showed that loading and unloading time represented 29% of the total journey time, whereas Table 4 indicated that the efficiency of these activities was 44%. Thus, these activities were considered the most inefficient factors of all the TOVE indicators. The authors provided three recommendations: increasing the resources for these activities by increasing the number of employees, considering the adoption of technology to automate these activities, and improving the activities using lean thinking. The company should evaluate the benefits, costs and trade offs of adopting new technology or staying with the same resources. However, the first option should be to try improving the current operations and the resources' skills before moving into automation.

d. Barcoding or RFID. Picking order to the outbound area is one of the activities that affected the TOVE with 9% of the total journey time, see Fig. 2(c). Inefficiencies in this activity come from the lack of an effective organisation inside the plant and uncontrolled inventory. Hence, lift truck drivers spend most of their time looking for orders around the plant. Authors suggested using technologies such as barcoding or radio-frequency identification (RFID) in order to locate their orders faster. Other solution was to implement lean thinking tools such as Kanban and 5S with the purpose of defining specific locations for each order and maintain an organised workplace.

e. GPS – traffic and navigation app. The TVSM analysis showed that IT activities accounted for 28% of the total journey time. Thus, there are aspects that are out of control of the company such as traffic jams or strikes, and the location of the company inside of the city does not help with the duration of the trucks in transit. Nevertheless, despite these external factors, the company can optimise the transit time and use the most efficient route according to the hour and extraordinary events in the city. The implementation of real time driving technology such GPSs and navigation apps was thus recommended.

f. Scheduling deliveries. Due to an extraordinary event, the item 'waiting time for available space in each customer' in the fifth observation had to be excluded in order to capture the real process, see Table 1. In this case, the delivery truck spent more than one day waiting in the queue. Despite this being an extraordinary event, Fig. 2(c) showed that this factor accounts for 9% of the total journey time, making it an imporant element to be improved. The authors suggested having a pre-arranged agreement with the customer where the case company and the client establish and agree upon a delivery schedule with specific delivering times. This would reduce the time that trucks spend in the queue.

g. Communication. Communication between employees, managers and customers is important in order to be more efficient throughout the supply chain. Some of the issues observed during the five routes observed were the lack of communication. For example, during the fifth observation the delivering truck spent more than one day, in the premises of the customer, waiting to be unloaded. This was the result of a lack of communication and coordination between the case organsiation and its client. Thus, the author suggestted finding other channels of communication such as chats, sharing online status of the operations, or having a strict schedule that facilitates the flow of the process.

4. Conclusions

This paper addresses the improvement of road transport operatons of a world leader manufacturer of paper-based packaging solutions operating in Bogota, Colombia. Unlike the traditionally used improvement approaches for this type of operations based on mathematical modelling and optimisation algorithms supported by powerful software tools, the improvement of the road transport operations in this case was based on the application of lean concepts, methods and tools. In particular, a TVSM analysis and measurement of performance through the TOVE metric were carried. Based on the outcome and results of these, improvement recommendations were proposed. Despite the recommendations still being evaluated for implementation by the case organisation and hence the results and success of the study have not been determined, the lean analysis based on TVSM and TOVE calculation has allowed the organisation to understand its performance and wasteful activities within its road transport operations. This paper adds to the lean thinking theory by providing further evidence of its application in a growingly important activity and industry for companies, nations and economies, i.e. logistics and transport.

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